Final Project

Due 11:59PM March 22, 2019.

For the final project, you have two options. Option 1 is to design a next generation vehicle to meet the 2025 CAFE standard. Option 2 is to design bus routes in Davis to reduce the emissions impact of the daily commuters to and from campus. The required simulator files can be found on the Canvas in zip file.

Option 1

The newly established 2025 CAFE standard calls for a 163 g $CO_{2\text{-eq.}}$/mile fleet average emissions rate. This fleet average will be achieved only with a significant market share for vehicles that are significantly below the fleet average. For 2013 vehicles, the most fuel-efficient, non-hybrid vehicles emit at a rate that is 58% of the fleet average standard. Assuming the fuel economy distribution remains similar, this translates into a vehicle that emits roughly 108 grams of $CO_{2\text{-eq}}$ per mile. For the final project of the course you will design a vehicle that will fill the role of most fuel efficient of the auto manufacturer's fleet.

The greenhouse gas emissions rates are measured based on the energy consumption for the city and highway drivecycles and the carbon intensity of the fuel used. The combined score will follow EPA's formula with 55% of miles assumed to be on the city drivecycle and 45% of miles on the highway drivecycle. The carbon intensity of the fuel $\left(\frac{gCO_{2-eq}}{MJ}\right)_{fuel}$ must be taken from the California Air Resources Board's lookup table for Low Carbon Fuel Standard compliance (included in the Final Project folder on Canvas). The equation below shows how to calculate the emission rate for a vehicle design.

$$\frac{gCO_{2-eq}}{mile} = \left(0.55 * \frac{MJ}{mile_{city}} + 0.45 * \frac{MJ}{mile_{highway}}\right) * \frac{gCO_{2-eq}}{MJ}_{fuel}$$

The LEV III standard was recently amended for vehicles of model year 2015 – 2025. In addition to the GHG target, your vehicle will be evaluated on tailpipe pollutants. Your vehicle should target SULEV20 and will be evaluated on how close it comes to meeting the target. The California Air Resources Board's lookup table for LEV III exhaust standard is included in the Final Project folder on Canvas.

The vehicle you design will be simulated use the python that we have been developing during the course for the problem sets. I have included an example python simulator for a conventional vehicle with a 5-speed automatic transmission and a 1.9L Saturn engine from 1999, a hybrid vehicle, and an electric vehicle in the Final Project folder on the Canvas.

Since you are not automotive engineers, I am not looking for the level of rigor that would be required to really know if your vehicle design would achieve the target, but instead I expect you to work with the tools you have and make an argument for this vehicle that you are designing. The python simulation is a rough approximation for vehicle simulation. You will need to adjust the vehicle design parameters listed below in order to reach the 108 $gCO_{2\text{-eq}}$/mile target and to meet the SULEV20 emissions standard.

Vehicle design parameters that you can vary:

- Weight
- Frontal area
- Coefficient of drag
- Coefficient of rolling resistance
- Engine BSFC across range of operating torque and rpm (if using an ICE) – This can be done by modifying the engine data files, or creating a new one.
- Engine maximum power (if using an ICE)
- Transmission efficiency and number of gears
- Any electric drive components (motors, generators, batteries, fuel cells, ultracaps)
- Any alternative power or energy storage devices (i.e. flywheels or hydraulic drive)
- Expected fuel to power the vehicle, its carbon intensity, resource limits and availability

You are encouraged to use a base vehicle from current model year or concept cars with enough published data in order to justify your choices for the above vehicle design parameters (for example: you can use a coefficient of drag of 0.19 and frontal area of ~2.8 m^2 for a small SUV by citing the Mercedes-Benz Bionic concept car). Several papers that can be useful are posted to the Canvas.

The vehicle you design should recognize several market requirements:

Acceleration: A slow vehicle in the current automotive market can go from 0-60 mph in about 10 seconds. A rough 0-60 mph time should be simulated.

Grade: Vehicles in current automotive market can maintain interstate speeds while going up a 6% grade for a long time. Test to see if the vehicle you design can accomplish this task. I've included a test simulation for whether the vehicle can maintain speed at 6% grade for 10 minutes.

Range: If designing an electric or fuel cell vehicle the range of the vehicle will need to be considered. The 2012 Nisan Leaf was rated at 73 mile range but it is uncertain how big the market niche is for low range vehicles.

Fuel availability: Is the fuel you are using widely available? If not, a discussion of the barriers related to fuel availability should be added to your report.

Report:
You will document your design by both providing your vehicle simulation spreadsheet and through a concise report. This report should document the design decisions you have made, justification for the values used (cite an existing vehicle, cite a report or walk me through your logic to get to the value used), and a brief discussion of the market acceptance of your vehicle design (Do you expect it to be an expensive or cheap vehicle? Is it relatively small or slow? Does it have limited range? Will consumers be able to find fuel?). These reports should be in the range of 5 to 10 pages long depending on your use of figures and how much explaining versus citing is done for your justification.

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Option 2

There are roughly 30,000 students and 30,000 employees that work and go to school at UC Davis. We will assume that these are distinct groups even though many of the employees are students as well. You will be designing bus routes and bike paths around Davis to reduce the number of individuals who are driving to campus each day. Assume that the campus does not currently have a Unitrans, Davis doesn't have its wonderful bike paths, and that parking is currently free. The plan is to offset the cost of building bike paths, purchasing buses, and operating the bus system with parking fees. The parking fees will also incentivize individuals to take the bus (also which may have a ridership fee). Two buses exist in the simulator; additional buses may be added with proper references.

The goal of the project is to reduce the average CO_2 per passenger mile travelled to 108 g $CO_{2\text{-eq.}}$/mile. The LEV III standard was recently amended for vehicles of model year 2015 – 2025. In addition to the GHG target, you will be evaluated on tailpipe pollutants per passenger mile travelled. You should target ULEV125 for light duty vehicles and will be evaluated on how close it comes to meeting the target. The California Air Resources Board's lookup table for LEV III exhaust standard is included in the Final Project folder on Canvas.

Files:
Bus routes, bus stops, and bike paths can be setup using the routebuildergui.py program (try updating Tk http://www.activestate.com/activetcl/downloads if having problems). The config.csv file holds the configuration for the simulation. You may set the Bus Cost (price to ride the bus), Max Bus Per Loop (maximum buses that will go out on a single busy loop), and Parking. You may set Employee Count and Student Count lower during testing, but final results must be set to 30,000. If you do reduce the counts for testing, you should drop the Student Ratio and Employee Ratio accordingly.

Report:
You will document transportation system plan through a concise report. This report should document the design decisions you have made, justification for the fees chosen or bus models introduced, and a brief discussion of the reduction in CO_2, HC, CO, NOx and PM. These reports should be in the range of 5 to 10 pages long depending on your use of figures and how much explaining versus citing is done for your justification.

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